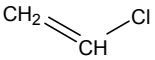
VINYL CHLORIDE
CAS No. 75-01-4
First Listed in the *First Annual Report on Carcinogens*



CARCINOGENICITY

Vinyl chloride is *known to be a human carcinogen* based on sufficient evidence of carcinogenicity in human (IARC S.7, 1987). Vinyl chloride has been associated with tumors of the liver, brain, lung, and hematolymphopoietic system. A large number of epidemiological studies and case reports have substantiated the causal association between vinyl chloride and angiosarcoma of the liver. Several studies also confirm that exposure to vinyl chloride causes other forms of cancer, i.e., hepatocellular carcinoma, brain tumors, lung tumors, and malignancies of the lymphatic and hematopoietic system. Exposure to poly(vinyl chloride) dust was associated with an increased incidence of lung tumors in one study; the authors suggested that trapped vinyl chloride monomer was responsible. Melanoma occurred in excess in one study but has not been mentioned in others. Slightly elevated risks for gastric and gastrointestinal cancer (other than liver cancer) were indicated in some studies, but these were not confirmed in others.

An IARC Working Group reported that there is sufficient evidence of carcinogenicity of vinyl chloride in experimental animals (IARC V.19, 1979; IARC S.4, 1982; IARC S.7, 1987). When administered by inhalation, vinyl chloride induced pulmonary adenomas and adenocarcinomas, mammary adenocarcinomas, liver angiosarcomas, and angiosarcomas and adenocarcinomas at other sites in mice of both sexes. Inhalation of vinyl chloride induced Zymbal gland carcinomas, nephroblastomas, and liver angiosarcomas in rats of both sexes and mammary tumors and hepatocellular carcinomas in female rats. When administered by inhalation, vinyl chloride induced skin tumors in male hamsters and angiosarcomas (liver, spleen, or skin), mammary carcinomas, skin carcinomas, and stomach adenomas in female hamsters. Newborn rats developed angiosarcomas and hepatomas when exposed to vinyl chloride by inhalation. A combination of oral administration of ethanol and inhalation of vinyl chloride resulted in more liver tumors (including angiosarcomas) than after treatment with vinyl chloride alone.

PROPERTIES

Vinyl chloride is a colorless, flammable gas with a faintly sweet odor. The gas polymerizes in light and liquefies in a freezing mixture. It is slightly soluble in water, soluble in ethanol, and very soluble in ether, carbon tetrachloride, and benzene. In the form of vapor, vinyl chloride is a dangerous fire and severe explosion hazard when exposed to heat, flame, or oxidizers. On standing, it forms peroxides in air and can then explode. On combustion, it is degraded mainly to carbon dioxide, carbon monoxide, hydrogen chloride, and traces of phosgene. Technical-grade vinyl chloride is commercially supplied as 99.9% pure liquid under pressure.

USE

Vinyl chloride is industrially important because of the inherent flame retardant properties of its polymer, its wide variety of end use products, and the low cost of producing polymers from it (ATSDR, 1997-K029). Because it has been confirmed that the monomer is a human and animal carcinogen, sale of propellants and all aerosols containing it was banned in 1974 (HSDB, 1997). Vinyl chloride is used almost exclusively in the United States by the plastics industry. The monomer is the parent compound of poly(vinyl chloride) (PVC), a plastic resin used in innumerable consumer and industrial products, including containers, wrapping film, battery cell separators, electrical insulation, water distribution systems (water and drain pipes, hose), flooring, windows, phonograph records, videodiscs, irrigation systems, and credit cards. In 1992, 98% of vinyl chloride monomer production was used to make PVC and its various polymers. Vinyl chloride-vinyl acetate copolymers are used extensively to produce vinyl-asbestos floor tiles (IARC V.7 1974; NCI DCCR 1978; IARC V.19, 1979; ATSDR, 1997-K029).

PRODUCTION

Steady production of vinyl chloride has placed the compound in *Chemical and Engineering News*'s top 50 list of high-volume chemicals produced in the United States for the past several years. Production steadily increased from 6-8 billion lb in 1983 to 15 billion lb in 1995 (Chem. Eng. News 1996 and USITC 1984 and 1985).

In 1994, imports of vinyl chloride totaled 29 million lb, compared to the 164 million lb in 1991. In 1989, a high of 302 million lb was imported. Since then, a steady decline of imports has been seen. On the other hand, exports have fluctuated fairly widely. In 1994, exports of vinyl chloride totaled 2.10 billion lb, an increase from the 1992 amount of 1.65 billion lb (ATSDR, 1997-K029). In 1987, total U.S. exports of vinyl chloride were 843 million lb, which was a decrease from the 1985 total export of 1.02 billion lb. The import volumes for 1986 and 1985 were reported to be 206 and 130 million lb, respectively. In 1983 import volumes totaled 686 million lb, while in 1982 export volumes totaled 50.7 million lb (HSDB, 1997).

EXPOSURE

The primary routes of potential human exposure to vinyl chloride are inhalation and dermal contact. Potential human exposure to vinyl chloride occurs in the workplace, through general air and water pollution, and to a limited extent, from the use of fabricated products (NCI DCCR, 1978). The major source of releases of vinyl chloride into the environment is believed to be emissions and effluents from plastics industries. Most of the vinyl chloride released into the environment will eventually locate in the atmosphere while much smaller amounts will eventually locate in ground water. Segments of the general population living in the vicinity of emission sources are potentially exposed to vinyl chloride by inhalation of contaminated air. Average daily intake of vinyl chloride by local residents ranges from trace amounts to 2,100 µg/day. The average daily intake of vinyl chloride by inhalation is expected to be essentially zero for the remainder of the population; however, new car owners are potentially exposed to relatively high levels due to volatilization of vinyl chloride from vinyl polymers within the car interior. It is also estimated that the average daily intake of vinyl chloride by ingestion of drinking water for the majority of the population is zero, since the majority of drinking water supplies do not contain detectable levels of the chemical. It has been reported that migration of vinyl chloride from rigid PVC water pipes into drinking water occurs and that it is directly proportional to the residual level of vinyl chloride in the pipe itself. Although the majority of the

general population is not expected to be exposed to vinyl chloride through ingestion of drinking water, EPA estimated in 1985 that about 0.9% of the U.S. population is exposed to levels from 1.0 to < 5 µg/L in their drinking water. The average daily intake of vinyl chloride from the diet is predicted to be essentially zero (ATSDR, 1997-K029). Vinyl chloride has also been detected in domestic and foreign cigarettes and little cigars at concentrations ranging from 5.6 to 27 ng/cigarette and in a marijuana cigarette at 5.4 ng/cigarette (IARC V.19, 1979).

Although large quantities of vinyl chloride are produced each year in the United States, it is not in the production of the chemical itself that the greatest potential for harmful exposure exists. Occupational exposures generally occur after production, as the finished monomer is piped to storage or transportation or during maintenance. The greatest potential for the hazard is during polymerization of the chemical to form other materials, nearly all of which are PVC resins, and the vinyl chloride escapes into the air (NCI DCCR, 1978). This has been the major emission source and the process in which the highest occupational exposures have been reported. The National Occupational Exposure Survey (1981-1983) estimated that 18,386 workers, including 7,384 women, were potentially exposed to vinyl chloride (NIOSH, 1984). NIOSH estimated that 27,000 workers are exposed to vinyl chloride and that as many as 2.2 million workers are potentially exposed (NIOSH 28, 1978). According to the Toxic Release Inventory of 1995, an estimated total of 1.01 million lb of vinyl chloride (99.9% of the total environmental releases) was discharged to the air, 227 lb (< 0.03%) to the water, and 6 lb (< 0.0006%) to the soil from manufacturing and processing facilities in the United States in 1993 (ATSDR, 1997-K029). ACGIH has designated an 8-hr time-weighted average (TWA) threshold limit value (TLV) for vinyl chloride of 5 ppm (13 mg/m^3) (ACGIH, 1996).

REGULATIONS

CPSC has banned self-pressurized products intended or suitable for household use that contain vinyl chloride as an ingredient or in the propellant. Under the Clean Air Act (CAA), National Emission Standards for Hazardous Air Pollutants (NESHAP) addresses vinyl chloride emissions from production and manufacturing facilities. A final rule reportable quantity (RQ) of 1 lb was established for this chemical under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). Under the Clean Water Act (CWA), EPA published a water quality criteria document addressing vinyl chloride for the protection of human health. EPA regulates vinyl chloride as a hazardous constituent of waste under the Resource Conservation and Recovery Act (RCRA). Under the Safe Drinking Water Act (SDWA), EPA established a maximum contaminant level (MCL) of 0.002 mg/L for vinyl chloride. Under the Superfund Amendments and Reauthorization Act (SARA) of 1986, EPA sets forth specific requirements for the submission of information relating to the release of vinyl chloride from covered facilities. FDA, which also sets the allowable level for the chemical at 0.002 mg/L in bottled water, regulates vinyl chloride monomer and polymers as food additives. Vinyl chloride as an ingredient in aerosol drug products has been determined to be a new drug; however, any cosmetic aerosol product containing vinyl chloride has been deemed to be adulterated by FDA. NIOSH recommends occupational exposure to vinyl chloride be limited to the lowest feasible concentration (NIOSHc, 1996). OSHA has adopted a permissible exposure limit (PEL) of 1 ppm for vinyl chloride as an 8-hr TWA, with a 5-ppm ceiling for any 15-minute period. OSHA requires medical surveillance, training for workers, use of protective clothing and respirators, warning signs, product labeling, and periodic monitoring for vinyl chloride in the workplace. OSHA, in addition, regulates vinyl chloride under the Hazard Communication Standard and as a chemical hazard in laboratories. Regulations are summarized in Volume II, Table A-43.